DRAFT Potential PM&E Measure - EWG – 16A:
Proposed Creation of Rearing Habitat for Juvenile Salmonid Fish Species

Date of Field Evaluation: June 11, 2003

Field Evaluation Team: Philip Unger and Jason Kindopp

Proposed PM&E:

Create side-channel habitat adjacent to the low-flow reach in the Feather River. DWR studies have found that juvenile steelhead trout strongly select shallow riffle/glide and near-shore habitats with abundant riparian and in-stream cover. Habitats meeting these criteria are most often found in side-channels. Currently preferred habitats of juvenile steelhead are not common in the low flow channel (LFC). To expand availability of preferred rearing habitat, side channels should be constructed at various suitable areas within the LFC.

Potential sites for side channel creation in the LFC include (from upstream to downstream): Aleck Riffle, Great Western Riffle, Robinson Riffle/Borrow Pond, Steep Riffle, between Eye and Gateway Riffles, and the OWA southeast of the Thermalito Outlet. Side channel creation will be most effective if conducted in combination with base flow increase, planting of riparian vegetation, and re-establishment of flow through historic river channels.

Potential Environmental Benefits:

The most immediate potential benefit of the proposed PM&E is an increase in rearing habitat for juvenile salmonids, but the primary potential benefit is an increase in the escapement levels of naturally produced steelhead trout and spring-run and fall-run Chinook salmon in the Feather River. Hatchery production of anadromous salmonids has a number of potential adverse effects on wild populations of these fish, so natural production should be favored whenever feasible. Secondary benefits of the PM&E include an increase in the forage base of striped bass, Sacramento pikeminnow and other predators of juvenile salmonids; an increase in habitat for riparian plant and wildlife species; and an increase in the aesthetic value of the river corridor.

Conditions in the Proposed PM&E Implementation Area:

Because of water temperature constraints, the LFC is currently the only portion of the lower Feather River suitable for year-around rearing of juvenile salmonids and is, by far, the most important section of the river for salmon and steelhead spawning. However, habitat with suitable depth, cover and flow velocity conditions for rearing salmonids is limited in the LFC. Rearing habitat in the LFC is particularly important for steelhead, which generally rear for several months to a year or more before

emigrating to sea, while most Feather River chinook begin their emigration within a month or two of emerging from their redds.

Juvenile steelhead and Chinook salmon have similar rearing habitat needs. Recent surveys by DWR fisheries biologists found juveniles of both species primarily in glide habitats with instream cover and/or overhead cover (e.g., canopy) (SP-F10 January 22, 2003 Interim Report). Most were found at shallow depths within a couple of meters of the shore. The juveniles of both species gradually shifted to greater use of riffle habitat with higher flow velocities as they grew larger, although the shift was somewhat more pronounced for steelhead than for salmon. Habitat with moderate flow velocity provides the juvenile salmonids with good feeding conditions, and shallow depth and abundance of cover provide refuge from predators. In large, low gradient rivers like the lower Feather River, side channels and tributaries typically provide the sort of riffle/glide, near-shore habitat with abundant cover that juvenile salmonids prefer. Such habitats are uncommon in the LFC.

The LFC of the Feather River can be divided into three reaches on the basis of habitat types. The upstream reach, from River Mile (RM) 67, below the Fish Barrier Dam, to the Highway 70 bridge (about RM 65.6), has a complex mix of riffle, glide and pool habitat, interspersed with a number of gravel mid-channel bars and channel side bars. Riparian vegetation is moderately well developed in portions of this reach. This reach has several side channels that provide some rearing habitat. The middle reach, which stretches from the Highway 70 bridge to Robinson Riffle at RM 62, has little gradient and is largely comprised of long, deep pools with highly uniform habitat conditions. Most of the riverbank in this reach is straight and steep and has little riparian vegetation. The only exception is an approximately one-mile section downstream of the Highway 162 bridge that includes three riffle/glide areas (Trailer Park Riffle, Mathews Riffle and Aleck Riffle). The Great Western Riffle, which lies in the lower section of the middle reach, is a low-gradient area filled with scattered debris of an old ruined dam. It provides little spawning or rearing habitat for salmonids. Little side channel habitat occurs in the middle reach of the LFC. The downstream reach of the LFC extends about 2.5 miles from Robinson Riffle to Gateway Riffle. This reach, which has more gradient than the middle reach, includes a series of pool, riffle and glide habitats. Gravel bars and mid-channel islands are plentiful in this reach and there is more riparian vegetation here than in the middle reach. Side channel habitat is more plentiful in this reach than in either of the other reaches. Gateway Riffle is about one half mile upstream of the Thermalito Afterbay outlet, which marks the downstream end of the LFC.

The distribution of rearing young-of-the-year salmonids in the LFC did not match the distribution of side channel habitat. Although side channel habitat is most plentiful in the downstream reach, the majority of young-of-the-year steelhead and salmon found during the DWR fisheries surveys were observed or captured in the upstream reach of the LFC (SP-F10 January 22, 2003 Interim Report). Most other fish species, including likely predators such as Sacramento pikeminnow and the black basses, largely avoid the LFC, presumably because of the low water temperatures.

As previously noted, Hatchery Ditch had by far the highest density of juvenile steelhead of any of the sampled sites. The authors of the SP-F10 report speculate that the upstream distribution of the young-of-the-year steelhead results from greater spawning by adult steelhead in the upstream reach. They suggest that the blockage of migrating fish by the Fish Barrier Dam and chemical/olfactory cues from the Feather River hatchery effluent cause most steelhead to spawn in the upstream reach. This spawning distribution would explain the concentration of recently emerged fry in the upstream reach. In contrast to young-of-the-year steelhead, age-1 and older juvenile steelhead distribution did match the distribution of side channel habitat.

The sites that have been proposed for creation of side channel habitat are primarily in the downstream reach of the LFC. These sites are Robinson Riffle/Borrow Pond, Steep Riffle, and the section between Eye and Gateway Riffles. The remaining two proposed sites, Aleck Riffle and Great Western Riffle, are in the middle reach.

Design Considerations and Evaluation:

Design Considerations

The most important design consideration for creating side channel habitat in the LFC concerns the flow regime of the river. Constructed side channel habitat would likely be altered or eliminated by flood flows. The Oroville Project is currently operated to maintain relatively low, uniform flows through the LFC. High flows occur only during periods of extreme runoff. Therefore, artificially created side channels have a high probability of persisting for a number of years with the current flow regime, although regular maintenance may be required. However, project operations could be altered to more closely mimic a natural flow regime, with frequent periods of high flow and periodic flood events. Frequent high flow events would likely alter or destroy artificially created side channels, defeating efforts at site-specific habitat creation. However, frequent high flows could lead to the formation of natural side channel habitats, particularly if some levees were breached to increase the area of flood plain. Ultimately, this might reduce the need for improving existing rearing habitat.

Another factor to consider in creating a side channel is the risk of causing a shift in the river channel. The new channel could be favored by the river, leading to channel erosion and ultimately abandonment of the old channel. Valuable spawning and rearing habitat could be lost. Evaluating this risk requires a deep understanding of the river's geomorphic processes.

Even without a shift in the river channel, diverting flow to side channel habitat would result in reduced flow in the main channel, with potential adverse effects on main channel habitat. However, in order to maintain the shallow depths and nearshore environment favored by juvenile salmonids, created side channel would have a small cross-sectional area that would require relatively little flow. For instance, the

Hatchery Ditch, which is highly productive for juvenile steelhead, typically flows at 25 cfs or less.

As described earlier, rearing juvenile salmonids favor habitat with moderate flow velocities, shallow depths, and abundant instream and overhead cover. Average focal point velocities for juvenile steelhead in the LFC increased with size of the fish from less than 0.1 feet per second (ft/s) to about 2 ft/s (SP-F10 January 22, 2003 Interim Report). Average depth ranged from about 0.2 to 0.4 meters and average distance from shore ranged from less than half a meter to about 2 meters. Microhabitat parameters for juvenile Chinook salmon were similar. The juveniles of both species were associated with small instream cover and overhead cover, but avoided large instream objects. The large instream objects were probably avoided because of their potential for sheltering predators.

Hydraulic modeling would be used to help design side channels with appropriate flow velocities and depths, while judicious routing of created channels through existing areas of vegetation combined with vegetation enhancement and other habitat enhancement measures would be used to provide good cover conditions. The most promising sites for creating suitable side channel habitat with the characteristics favored by juvenile salmonids occur on gravel bars bordering riffles in the main river channel. Sites adjoining riffles are the only areas with sufficient gradient to ensure that the created side channels would have sufficient flow velocities for the rearing salmonids. Several of the proposed sites have fairly well developed riparian vegetation that would provide excellent overhead cover for the side channel habitat. It is likely that riparian vegetation would recruit along side channels constructed through areas currently lacking vegetation, although artificial enhancement of vegetation would likely result in more rapid development of suitable cover.

Construction of side channel habitat would require moving large volumes of gravel using heavy earth-moving equipment. Such activities have the potential to produce water quality problems, particularly high turbidity. Therefore, construction of the side channels should be restricted to a time of year when sensitive life stages of the salmonids are least abundant in the river. Spring-run Chinook salmon spawn from about mid August through October, fall-run Chinook spawn from about September through December, and steelhead spawn from about November through June. Fry of all three species emerge from their redds in the late winter or spring and most of the salmon have emigrated by June. Therefore, July through mid-August is probably the best period of the year for avoiding impacts on sensitive life stages of these species. In addition, the July to mid-August period has little rainfall and low river flows, so mobilization of disturbed sediments would be minimized at this time.

The success of side channel habitat creation would be judged on the basis of numbers and growth rates of juvenile salmonids found in the channels several years after the habitats were created.

Site Evaluations

None of the proposed sites for side channel development are in the upstream reach of the LFC. However, two existing side channels in this reach, Hatchery Ditch and Moe's Ditch, have been proposed for habitat restoration efforts (PM&E ID: EWG-16B). Given the importance of the upstream reach for juvenile rearing, rearing habitat in this reach is particularly important.

Two of the proposed sites for side channel creation, Aleck Riffle and Great Western Riffle, are in the middle reach of the LFC. As previously noted, the middle reach has a dearth of suitable rearing habitat, so habitat created in this reach, if effective, would likely have great value for steelhead and salmon production. The Aleck Riffle site sits on a channel side bar that extends about ¾ mile downstream of Aleck Riffle (RM 63.5) on the east bank of the river. The inshore margin of this bar (nearest the levee) has riparian vegetation that would provide good cover if a side channel was routed through it. Gradient at Aleck Riffle may be insufficient for creation of a side channel that would run the entire ¾ mile length of the side bar. If that were the case, a shorter section of the bar, beginning at the upstream end, would be used (Figure 1).

The proposed Great Western Riffle site lies on an open gravel bench along the west bank of the river next to Great Western Riffle (about RM 62.8). Inspection of this site revealed some drawbacks. First, the river has little gradient at this location (Figure 2). As noted above, potential sites need gradient to produce adequate flow velocity in the created side channel. Second, most of the site is located on a bench that would be inundated only at very high flows. And finally, the site currently has little vegetation (Figure 2).

The rest of the proposed sites for side channel creation are in the downstream reach of the LFC. This reach generally has a higher gradient, more gravel bars, and more riparian vegetation than the middle reach. The reach currently seems to be especially important for rearing age 1+ steelhead and probably provides valuable habitat for emigrating salmon and steelhead. The most upstream site proposed for side channel creation in the reach is the Robinson Riffle/Borrow Pond site (between RM 62 and RM 61). This site has a very complex geomorphology, largely because existing side channels connect the main channel of the river, upstream and downstream, to Robinson Pool, a large borrow pond (Figure 1). These side channels were created by the 1997 flood (Jason Kindopp, DWR, personal communication). A significant portion of the Feather River discharge flows through Robinson Pool. One promising route for creating a side channel at this site runs from the upper end of the existing upstream side channel between the river and Robinson Pool (Figure 3), along the pool side of a berm that separates the pool from the river channel, and into the existing downstream side channel connecting the pool and river (Figure 1). This route, which is approximately 2/5 of a mile long, appears to have adequate gradient and has abundant riparian vegetation along the lower half of the route (Figure 3).

The next proposed site for side channel creation begins just upstream of Steep Riffle at RM 61 (Figure 4). Steep Riffle has a high gradient. Its lower end joins the existing downstream side channel connecting the river to Robinson Pool (Figures 1 and 5). The most likely route for a constructed side channel at this site would begin in the backwater area on the upstream face of the large gravel bar that lies along the north bank of Steep Riffle (Figure 4). This gravel bar is about ¼ mile long. A strip of well-developed riparian vegetation lies along the levee side of this gravel bar, and this strip appears to be a natural route for a side channel (Figure 5). Because the gradient of the river at Steep Riffle is so high, it might be possible to provide additional side channel habitat on the gravel bar by creating a meandering side channel. The constructed side channel could rejoin the river at the downstream end of the gravel bar (Figure 4). Alternatively, assuming enough gradient is available, the side channel could be extended beyond the large gravel bar and downstream along the levee to Eye Riffle (about RM 60) (Figures 4 and 6). As described below, the section between Eye Riffle and Gateway Riffle (Figure 6) is the final proposed site for side channel creation. If this site were found to be suitable for side channel creation, if might be possible to join the Steep Riffle side channel to the Eye Riffle - Gateway Riffle channel, thus creating a side channel that would reach from Steep Riffle to Gateway Riffle, about 1.5 miles (Figure 4).

A potential course for a side channel at the proposed site between Eye Riffle and Gateway Riffle would run along a swale on the levee side of a gravel bar that stretches ½ mile along the north bank of the river, from upstream of Eye Riffle to the middle of Gateway Riffle (about RM 60.2 to RM 59.7) (Figure 4). This swale is bordered by dense growth of riparian trees and shrubs. Water sits in the upper and lower ends of the swale, creating deep narrow backwater areas (Figure 7). No current was visible in the water at either end of the swale during the field visit, which suggests that the upstream and downstream inundated areas are disconnected. The gradient between Eye Riffle and Gateway Riffle may not be sufficient to provide adequate flow velocity in a side channel running the entire distance of the gravel bar. If the gradient was not sufficient, the side channel could be directed back to the river upstream of Gateway Riffle.

Recommendations:

One of the main factors that should be considered in evaluating the feasibility of this PM&E is the likely persistence of any created side channel habitat. More than anything else, this will depend on the frequency, duration and amplitude of high flow events. If the LFC is to continue to receive relatively uniform flows, with only occasional extreme flows, created side channel habitat would be likely to persist for a number of years. However, even under the current flow regime, created side channel habitat may require regular maintenance and periodic reconstruction. According to DFG staff, Moe's Ditch, which was constructed during the 1970s and is the only artificially created side channel currently present in the LFC, had to be

regraded almost every year for a period after it was constructed (Koll Buer, DWR, personal communication). It has been completely destroyed and reconstructed several times. The ditch is currently dammed by beavers and has little habitat value for juvenile salmonids. If Oroville Project operations were modified to create more frequent high flow events in the future, artificially created side channel habitat would likely have a short life span.

As previously indicated, the upstream reach of the LFC is the most important area for rearing juvenile steelhead. While habitat restoration has been proposed for two side channels in this area, Hatchery Ditch and Moe's Ditch (EWG-16B), no sites in this reach have been proposed for side channel creation. Given the importance of rearing habitat in the upstream reach, sites for creating new side channel habitat in the reach should be considered.

Figure 1. Potential Side Channels: Aleck Riffle (top), Robinson to Steep Riffle (bottom)

Figure 2. Great Western Riffle: Ruined Dam (top), Cobble Bench (bottom)

Figure 3. Robinson Riffle: Side Channel (in background, top), Gravel Bar (bottom)

Figure 4. Potential Side Channels: Steep Riffle (top), Steep Riffle to Eye Riffle to Gateway Riffle (bottom)

Figure 5. Steep Riffle: Base of Riffle w/ Side Channel at Right (top), Gravel Bar (bottom)

Figure 6. Eye Riffle with Rotary Screw Trap (top), Gateway Riffle (bottom)

Figure 7. Inundated Swale Between Eye Riffle and Gateway Riffle (top and bottom)

DRAFT Potential PM&E Measure - EWG – 16B:
Proposed Restoration/Improvement of Rearing Habitat for Juvenile Salmonid Fish Species

Date of Field Evaluation: June 11, 2003

Field Evaluation Team: Philip Unger and Jason Kindopp

Proposed PM&E:

Restore and/or improve side-channel habitat adjacent to the low-flow reach in the Feather River. The two existing side channels at the upstream end of the LFC, Hatchery Ditch and Moe's Ditch, would benefit from habitat and flow enhancements. Hatchery Ditch, a primary steelhead spawning and rearing reach, is currently fed solely by seepage from the Feathery River Hatchery (FRH) settling pond. Discharge in Hatchery Ditch is directly related to water use in the hatchery. Hatchery Ditch requires its own water source for several reasons. Firstly, there may be water quality issues associated with the FRH effluent. Secondly, chemical/olfactory attraction from the Feather River hatchery effluent may result in stacking up of steelhead spawners and superimposition of redds. Thirdly, seepage from the settling pond percolates through the levee, which may cause damage to the levee. And finally, the ditch needs to be able to function independently of the FRH to allow maintenance on the FRH flowline. This need is particularly pressing since the FRH flowline is overdue for a major overhaul, which requires shutting down the hatchery water supply for several months.

Moe's Ditch is an artificial spawning channel adjacent to Hatchery Ditch. Currently Moe's Ditch lacks flow due to upstream changes in bed morphology a lack of cover and lack of channel sinuosity.

Potential Environmental Benefits:

The most immediate potential benefit of the proposed PM&E is an increase in rearing habitat for juvenile salmonids, but the primary potential benefit is an increase in the escapement levels of naturally produced steelhead trout and spring-run and fall-run Chinook salmon in the Feather River. Hatchery production of anadromous salmonids has a number of potential adverse effects on wild populations of these fish, so natural production should be favored whenever feasible. The majority of young-of-the-year steelhead and salmon found during recent surveys by DWR fisheries biologists were observed or captured in the upstream reach of the LFC (SP-F10 January 22, 2003 Interim Report). Hatchery Ditch had by far the highest density of juvenile steelhead of any of the sampled sites. Given the importance of Hatchery Ditch and other areas within the upstream reach for salmonid production, rearing habitat in this reach is particularly important.

Secondary benefits of the proposed PM&E include an increase in the forage base of striped bass, Sacramento pikeminnow and other predators of juvenile salmonids; an increase in habitat for riparian plant and wildlife species; and an increase in the aesthetic value of the river corridor.

Conditions in the Proposed PM&E Implementation Area:

Because of water temperature constraints, the LFC is currently the only portion of the lower Feather River suitable for year-around rearing of juvenile salmonids and is, by far, the most important section of the river for salmon and steelhead spawning. However, habitat with suitable depth, cover and flow velocity conditions for rearing salmonids is limited in the LFC. Rearing habitat in the LFC is particularly important for steelhead, which generally rear one to two years before emigrating to sea. Most Feather River chinook begin their emigration within a month or two of emerging from their redds. However, with more favorable rearing habitats the residency period of Chinook salmon could probably be increased.

Juvenile steelhead and Chinook salmon have similar rearing habitat needs. The DWR fisheries surveys found juveniles of both species primarily in glide habitats with instream cover and/or overhead cover (e.g., canopy) (SP-F10 January 22, 2003 Interim Report). Most were found at shallow depths within a couple of meters of the shore. The juveniles of both species gradually shifted to greater use of riffle habitat with higher flow velocities as they grew larger, although the shift was somewhat more pronounced for steelhead than for salmon. Habitat with moderate flow velocity provides the juvenile salmonids with good feeding conditions, and shallow depth and abundance of cover provide refuge from predators. In large, low gradient rivers like the lower Feather River, side channels and tributaries typically provide the sort of riffle/glide, near-shore habitat with abundant cover that juvenile salmonids prefer. Such habitats are uncommon in the LFC.

The LFC of the Feather River can be divided into three reaches on the basis of habitat types. The upstream reach, from River Mile (RM) 67, below the Fish Barrier Dam, to the Highway 70 bridge (about RM 65.6), has a complex mix of riffle, glide and pool habitat, interspersed with a number of gravel mid-channel bars and channel side bars. Riparian vegetation is moderately well developed in portions of this reach. Hatchery Ditch and Moe's Ditch are in the upstream portion of this reach. The middle reach of the LFC, which stretches from the Highway 70 bridge to Robins on Riffle at RM 62, has little gradient and is largely comprised of long, deep pools with highly uniform habitat conditions. Most of the riverbank in this reach is straight and steep and has little riparian vegetation. The only exception is an approximately one-mile section downstream of the Highway 162 bridge that includes three riffle/glide areas (Trailer Park Riffle, Mathews Riffle and Aleck Riffle). Little side channel habitat occurs in the middle reach of the LFC. The downstream reach of the LFC extends about 2.5 miles from Robinson Riffle to Gateway Riffle. This reach includes a series of pool, riffle and glide habitats. Gravel bars and mid-channel

islands with riparian vegetation are common in this reach and side channel habitat is more plentiful in this reach than in either of the other reaches.

The distribution of rearing young-of-the-year salmonids in the LFC did not match the distribution of side channel habitat. Although side channel habitat is most plentiful in the downstream reach, the majority of young-of-the-year steelhead and salmon found during the DWR fisheries surveys were observed or captured in the upstream reach of the LFC (SP-F10 January 22, 2003 Interim Report). As previously noted, Hatchery Ditch had by far the highest density of juvenile steelhead of any of the sampled sites. The authors of the SP-F10 report speculate that the upstream distribution of the young-of-the-year steelhead results from greater spawning by adult steelhead in the upstream reach. They suggest that the blockage of migrating fish by the Fish Barrier Dam and chemical/olfactory cues from the Feather River hatchery effluent cause most steelhead to spawn in the upstream reach. This spawning distribution would explain the concentration of recently emerged fry in the upstream reach. In contrast to young-of-the-year steelhead, age-1 and older juvenile steelhead distribution did match the distribution of side channel habitat.

Hatchery Ditch is a narrow, shallow, heavily shaded channel that runs about ¼ mile along the base of the levee separating the FRH from the LFC (Figures 1 and 2). Well-developed riparian vegetation, including a number of large cottonwood trees, borders the ditch, affording it excellent cover. Flow velocity in much of the ditch was moderately high. Most of the channel has clean gravel substrate and the ditch is heavily used for spawning by steelhead (Jason Kindopp, DWR, personal communication). Inspection of the substrate during the field visit revealed many benthic macroinvertebrates. A long gravel bar lies between Hatchery Ditch and the main channel of the river. Moe's Ditch also sits on this bar.

As previously indicated, seepage from the Feather River Hatchery (FRH) settling pond is the sole source of flow to Hatchery Ditch. Prior to the 1997 flood, Hatchery Ditch apparently had less flow and the flow percolated into the gravel, so the ditch was not connected to the river (Koll Buer, DWR, personal communication). It appears that the flood opened the channel and may have affected the levee, increasing the rate of seepage from the settling pond into the ditch (Jason Kindopp, DWR, personal communication). Currently, discharge in Hatchery Ditch is directly related to water use in the hatchery. During the field visit to the site, the settling pond retained little of the water discharged into it and the water appeared to seep rapidly through the levee into Hatchery Ditch (Figure 3). Several large, rapidly flowing seeps were found at the base of the levee near the upstream end of the ditch (Figure 4). The elevation of the channel in this area was several feet higher than that of the river. Because Hatchery Ditch does not get its flow from the river channel and because its upstream end has a higher elevation than that of the river channel, it currently functions more like a tributary than a side channel.

Moe's Ditch is a broad, straight, exposed man-made channel adjacent to Hatchery Ditch (Figures 1 and 5). The channel was initially constructed in the 1970s to

enhance salmonid spawning. The ditch has been regraded many times and complete reconstruction has been required after several flood events. The ditch was adversely affected by the 1997 flood and currently provides little spawning or rearing habitat. Young willows border much of the ditch, but they provide little cover.

Moe's Ditch begins at the upstream end of Auditorium Riffle and flows downstream over the gravel bar for about 1/7th of a mile, where it discharges back to the river. The upstream end is clogged with gravel that restricts flow in the channel. Apparently, such blockage has been a frequent problem for the channel (Koll Buer, DWR, personal communication). Because of the low flow, shallow depths and exposure, substrate at the upper end of Moe's Ditch is blanketed with algae. Beavers have constructed a dam near the lower end of the ditch; so much of the channel has been converted into a pool. Because of low flow, vegetation is heavily encroaching into the channel at the downstream mouth of the ditch (Figure 5).

Design Considerations and Evaluation:

The most important design consideration for restoring and improving rearing habitat in Hatchery Ditch and Moe's Ditch concerns the flow regime of the river. Habitat improvements made in these channels would likely be altered or destroyed by flood flows. The Oroville Project is currently operated to maintain relatively low, uniform flows through the LFC. High flows occur only during periods of extreme runoff. Therefore, habitat improvements in these channels have a high probability of persisting for several years with the current flow regime, although regular maintenance would likely be required. However, project operations could be altered to more closely mimic a natural flow regime, with frequent periods of high flow and periodic flood events. Frequent high flow events would likely alter or destroy habitat improvements or eliminate the channels entirely, defeating habitat restoration and improvement efforts. However, frequent high flows could lead to the formation of natural side channel habitats, particularly if some levees were breached to increase the area of flood plain. Ultimately, this might reduce the need for improving existing rearing habitat..

The most critical habitat improvement need for Hatchery Ditch is to provide a source of water other than the current FRH source. The current situation is unsustainable because of potential water quality issues, over-attraction of steelhead spawners, levee damage, and pressing FRH flowline maintenance needs. Because the upstream end of the Hatchery Ditch channel sits at a higher elevation than that of the adjacent river channel, flow cannot be provided to the ditch by breaching the bar that separates the two channels. Two alternatives have been proposed for diverting river water into the channel. One solution would be to pump water from the river into the upstream end of the channel. The channel currently receives up to 25 cfs, which would require a large pump, but less flow may suffice (Jason Kindopp, DWR, personal communication). In any case, the pump would be too large to be portable and would therefore have to be installed well above flood stage. Other potential

solutions would be to construct a flowline to divert water from an upstream location in the main river channel or from the Fish Barrier Dam pool. All of these alternatives would be costly.

Most physical habitat conditions within the Hatchery Ditch channel appear to be good for salmonid rearing habitat. As described earlier, rearing juvenile salmonids favor habitat with moderate flow velocities, shallow depths, and abundant instream and overhead cover. Average focal point velocities for juvenile steelhead in the LFC increased with size of the fish from less than 0.1 feet per second (ft/s) to about 2 ft/s (SP-F10 January 22, 2003 Interim Report). Average depth ranged from about 0.2 to 0.4 meters and average distance from shore ranged from less than half a meter to about 2 meters. Microhabitat parameters for juvenile Chinook salmon were similar. The juveniles of both species were associated with small instream cover and overhead cover, but avoided large instream objects. The large instream objects were probably avoided because of their potential for sheltering predators. The Hatchery Ditch channel is heavily shaded and is well provided with instream and overhead cover (Figure 1). The channel is generally less than half a meter deep and less than three meters wide, so rearing juveniles are never far from the stream bank. However, during the field visit, flow velocities in some sections of the channel appeared to be high for small young-of-the year salmonids. These sections were relatively straight with uniform substrates and the flows were uniform and swift, providing few flow velocity refuges for small fish (Figure 4). Introducing instream structures in these sections would produce flow breaks that would likely improve the habitat.

Juvenile steelhead collected in Hatchery Ditch typically had full stomachs, so feeding conditions are probably adequate (Jason Kindopp, DWR, personal communication).

Habitat conditions in Moe's Ditch contrast sharply with those in Hatchery Ditch. Moe's Ditch is quite broad and has little flow. A beaver dam backs up the flow in much of the channel, creating a large area of pool habitat. The most immediate need for restoring habitat in Moe's Ditch is to remove the gravels that restrict flow from the river channel. If the channel was opened the flow entering the ditch might wash out the beaver dam. Otherwise the dam would have to be removed mechanically.

The broad channel of Moe's Ditch is suitable for spawning habitat, which was the original objective of the habitat design, but it is too exposed to provide good rearing habitat. A new, narrower channel in the same area would provide better rearing habitat and would be easier to maintain with adequate flows. In addition, a narrower channel could more easily be routed through existing riparian vegetation or be enhanced with vegetation improvements to provide instream and overhead cover. Finally, a narrow channel could be provided with meanders to create more habitat complexity, including variable flow velocities. Hydraulic modeling could be used to help design a channel producing flow velocities and depths suitable for rearing salmonids.

Restoration of Moe's Ditch habitat would require moving large volumes of gravel using heavy earth-moving equipment. Such activities have the potential to produce water quality problems, particularly high turbidity. Therefore, the earth-moving activities should be restricted to a time of year when sensitive life stages of the salmonids are least abundant in the river. Spring-run Chinook salmon spawn from about mid August through October, fall-run chinook spawn from about September through December, and steelhead spawn from about November through June. Fry of all three species emerge from their redds in the late winter or spring and most of the salmon have emigrated by June. Therefore, July through mid-August is probably the best period of the year for avoiding impacts on sensitive life stages of these species. In addition, the July to mid-August period has little rainfall and low river flows, so mobilization of disturbed sediments would be minimized at this time.

The success of habitat restoration and improvement in Hatchery Ditch and Moe's Ditch would be judged on the basis of numbers and growth rates of juvenile salmonids found in the channels several years after the habitats were restored.

Recommendations:

One of the main factors that should be considered in evaluating the feasibility of this PM&E is the likely persistence of any habitat restorations or improvements implemented in Hatchery Ditch and Moe's Ditch. More than anything else, this will depend on the frequency, duration and amplitude of high flow events. If the LFC is to continue to receive relatively uniform flows, with only occasional extreme flows, habitat restorations and improvements would be likely to persist for a number of years. However, even under the current flow regime, the habitats may require regular maintenance and periodic reconstruction. According to DFG staff, Moe's Ditch had to be regraded almost every year for a period after it was constructed (Koll Buer, DWR, personal communication). It has been completely destroyed and reconstructed several times. If Oroville Project operations were modified to create more frequent high flow events in the future, improvements and restorations in the habitat of the ditches could have a short life span.

Figures

Figure 1. Hatchery Ditch and Moe's Ditch

Figure 2. Hatchery Ditch: Abundant Instream Cover and Overhead Cover (top and bottom)

Figure 3. Feather River Hatchery Settling Ponds (top and bottom)

Figure 4. Hatchery Ditch: Source (top), Straight Channel with Uniform Flow (bottom)

Figure 5. Moe's Ditch: Upstream End (top), Downstream End (bottom)